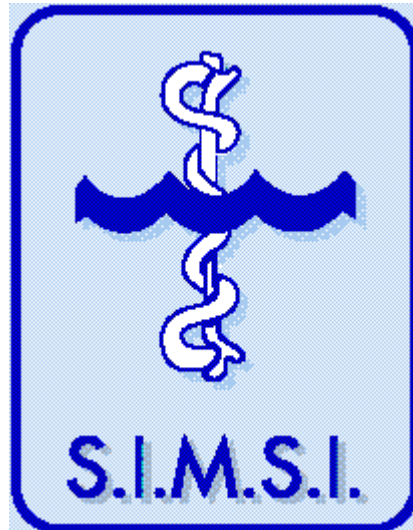
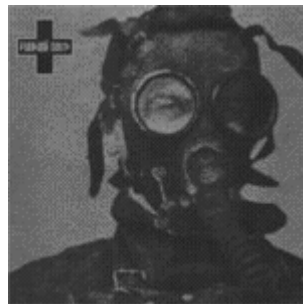


**SOCIETA' ITALIANA
DI
MEDICINA SUBACQUEA E IPERBARICA**



**RICERCA IN MEDLINE DEI LAVORI DI
MEDICINA SUBACQUEA
INDICIZZATI CON PAROLA CHIAVE**



**2006
PRIMO SEMESTRE**

a cura del
Dott. Francesco Ruocco
Servizio di Medicina Iperbarica e Subacquea
Anestesia e Rianimazione del Dipartimento di Emergenza
della Azienda Ospedaliera Universitaria di Careggi

Search "Diving"[MAJR] Limits: Publication Date from 2006/01 to 2006/06

**Search "Diving"[MAJR] Limits:
Publication Date from 2006/01 to
2006/06**

1: J Soc Biol. 2006;200(3):257-63.
[Diving: barometric pressure and
neurochemical mechanisms]
[Article in French]
Rostain JC, Balon N.
Université de la Méditerranée,
Institut de Médecine Navale du
Service de Santé des Armées EA3280,
Physiopathologie et Action
Thérapeutique des Gaz sous Pression,
IFR Jean Roche, Faculté de Médecine
Nord, Marseille, France.
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The studies of Paul Bert, presented
in his book "La Pression
Barométrique" in 1878, were at the
origin of the modern hyperbaric
physiology. Indeed his research
demonstrated the effects of oxygen
at high pressure, that compression
effects must be dissociated from
decompression effects, and that
neurological troubles and death of
divers during or after decompression
were due to the fast rate of
decompression. However, it is only
in 1935 that the work of Behnke et
al. attributed the complaints
reported at 3 bars and above in
compressed air or nitrogen-oxygen
mixture to the increase in partial
pressure of nitrogen which induces
nitrogen narcosis. Little is known
about the origins and mechanisms of
this narcosis. The traditional view
was that anaesthesia or narcosis
occurred when the volume of a
hydrophobic membrane site was caused
to expand beyond a critical amount
by the absorption of molecules of a
narcotic gas. The observation of the
pressure reversal effect during
general anaesthesia has long
supported this lipid theory.
However, recently, protein theories
have met with increasing recognition
since results with gaseous
anaesthetics have been interpreted
as evidence for a direct gas-protein
interaction. The question is to know
whether inert gases, that disrupt
dopamine and GABA neurotransmissions
and probably glutamatergic

neurotransmission, act by binding to
neurotransmitter protein receptors.
Publication Types: Biography
English Abstract Historical
Article
Personal Name as Subject: Bert
P
PMID: 17417141

2: Int J Sport Nutr Exerc Metab.
2006 Jun;16(3):281-95.
Body composition, dietary intake,
and iron status of female collegiate
swimmers and divers.
Petersen HL, Peterson CT, Reddy MB,
Hanson KB, Swain JH, Sharp RL,
Alekel DL.
Iowa State University, Ames 50011,
USA.
This study determined the effect of
training on body composition,
dietary intake, and iron status of
eumenorrhic female collegiate
swimmers (n = 18) and divers (n = 6)
preseason and after 16 wk of
training. Athletes trained on
dryland (resistance, strength,
flexibility) 3 d/wk, 1.5 h/d and in-
water 6 d/wk, nine, 2-h sessions per
week (6400 to 10,000 kJ/d). Body-
mass index (kg/m²; P = 0.05), waist
and hip circumferences (P < or =
0.0001), whole body fat mass (P =
0.0002), and percentage body fat (P
< or = 0.0001) decreased, whereas
lean mass increased (P = 0.028).
Using dual-energy X-ray
absorptiometry, we found no change
in regional lean mass, but fat
decreased at the waist (P = 0.0002),
hip (P = 0.0002), and thigh (P =
0.002). Energy intake (10,061 +/-
3617 kJ/d) did not change, but
dietary quality improved with
training, as reflected by increased
intakes of fiber (P = 0.036), iron
(P = 0.015), vitamin C (P = 0.029),
vitamin B-6 (P = 0.032), and fruit
(P = 0.003). Iron status improved as
reflected by slight increases in
hemoglobin (P = 0.046) and
hematocrit (P = 0.014) and decreases
in serum transferrin receptor (P <
or = 0.0001). Studies are needed to
further evaluate body composition
and iron status in relation to
dietary intake in female swimmers.
Publication Types: Research
Support, Non-U.S. Gov't
PMID: 16948484

3: J Interv Card Electrophysiol. 2006 Apr;15(3):179-83. Epub 2006 Aug 10.

Activity-based rate-adaptive pacemakers under hyperbaric conditions.

Trigano A, Lafay V, Blandeau O, Levy S, Gardette B, Micoli C.

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OBJECTIVES: The aim of this study was to test a variety of currently available activity-based rate-adaptive pacemakers under hyperbaric conditions. BACKGROUND: Sports divers with pacemakers can dive under certain circumstances. The rate response of activity-sensing pacing under hyperbaric conditions has rarely been evaluated. MATERIALS

AND METHODS: We manufactured a miniaturized hyperbaric chamber. A pacemaker inside was kept close to the corresponding telemetry wand placed on top of the chamber. An inflation device for coronary balloon angioplasty was used to create hydraulic pressure. Group I pacemakers were exposed to a 30 msw/98 fsw/4 ATA and after a 1-month waiting period to 60 msw/197 fsw-depth/7 ATA. Group II was exposed to only one dive to 60 msw. The electrogram and event marker telemetry were used to monitor the pacing stimuli and measurements were made for case distortion. RESULTS:

The baseline pacing rate did not change in 27 tests. Return to baseline was shown during 18 tests after transient sensor-driven rate. There was a sensor rate response to manual brief shaking during and following testing. A case distortion was shown in 15 of 29 tests at 60 m. CONCLUSIONS: Modern accelerometers showed no sensitivity to pressure on the pacemaker can at 30 msw/98 fsw and 60 msw/197 fsw but in some devices responded to pressure changes. There was no pacing dysfunction or suppression of the sensor response despite the high incidence of case distortion at 60 msw/197 fsw. As a general rule, diving should not be allowed at depths greater than 20 msw/65 fsw.

Publication Types: Comparative Study Evaluation Studies

PMID: 16900412

4: Travel Med Infect Dis. 2006 May-Jul;4(3-4):238-54. Epub 2005 Sep 28. Diving medicine.

Benton PJ, Glover MA.

Institute of Naval Medicine, Alverstoke, Gosport, Hampshire, PO12 2DL, UK.

Recreational diving developed in the late 1940s when self-contained underwater breathing apparatus (SCUBA) first became available for civilian use. At the same time the development of the commercial airliner, in particular the jet airliner, made possible the concept of international travel for pleasure as opposed to business. Over the past 50 years the number of international tourists has increased by over 2500% from a mere 25 million in 1950 to over 700 million in 2002 (Treadwell TL. Trends in travel. In: Zuckerman JN, editor. Principles and practice of travel medicine, 2001; p. 2-6). The popularity of recreational diving has also increased over the same period from an activity experienced by a small number of individuals in the early 1950s to an activity today enjoyed by many millions. The combination of increased international travel and the means by which to enter and explore the underwater world has led to diving becoming increasingly popular as a tourist activity.

Publication Types: Review

PMID: 16887745

5: Respir Physiol Neurobiol. 2006 Nov;154(1-2):118-38. Epub 2006 Apr 28.

The evolution of a physiological system: the pulmonary surfactant system in diving mammals.

Foot NJ, Orgeig S, Daniels CB.

Discipline of Environmental Biology, School of Earth & Environmental Sciences, University of Adelaide, Adelaide, SA 5005, Australia.

Pulmonary surfactant lines the alveolar air-water interface, varying surface tension with lung volume to increase compliance and prevent adhesion of respiratory surfaces. We examined whether the surfactant system of diving mammals exhibits adaptations for more efficient lung function during diving, to complement other respiratory adaptations. Here we review adaptations at the molecular, compositional, functional and

cellular levels and during development for animals beginning life on land and progressing to an aquatic environment. Molecular adaptations to diving were examined in surfactant protein C (SP-C) from terrestrial, semi-aquatic and diving mammals using phylogenetic analyses. Diving species exhibited sites under positive selection in the polar N-terminal domain. These amino acid substitutions may lead to stronger binding of SP-C to the phospholipid film and increased adsorption to the air-liquid interface. The concentration of shorter chain phospholipid molecular species was greater and SP-B levels were lower in diving than terrestrial mammals. This may lead to a greater fluidity and explain the relatively poor surface activity of diving mammal surfactant. There were no consistent differences in cholesterol between diving and terrestrial mammals. Surfactant from newborn California sea lions was similar to that of terrestrial mammals. Secretory activity of alveolar type II epithelial cells of sea lions demonstrated an insensitivity to pressure relative to sheep cells. The poor surface activity of diving mammal surfactant is consistent with the hypothesis that it has an anti-adhesive function that develops after the first entry into the water, with a surfactant film that is better suited to repeated collapse and respreading.

Publication Types: Research Support, Non-U.S. Gov't Review
PMID: 16877052

6: Undersea Hyperb Med. 2006 May-Jun;33(3):211-6.

Blood biochemical parameters in women during long-term simulated hyperoxic diving up to 8 ATA.

Popova J, Buravkova L.
SSC - Institute for Biomedical Problems RAS, Moscow, Russia.

Nowadays an increasing number of women are participating in recreational diving. A special recompression treatment table for delayed pulmonary barotrauma or decompression sickness was developed by V.V. Smolin in the Institute for Biomedical Problems (IBMP, Russia). The aim of our study was to investigate the effect of simulated

dives (similar to this recompression treatment table) on biochemical parameters of healthy women. Three healthy female volunteers participated in long-term simulated diving to 8 ATA (0.8 MPa). Blood samples for determination of the biochemical substrate levels and activity of blood enzymes using a Reflotron analyzer were obtained at the control period, at the beginning of decompression and at the post dive period. No significant changes of serum levels of glucose, triglycerides, cholesterol, HDL cholesterol and urea were found during this experimental period or in comparison with the predive values. There were no significant changes in ALT activity in two volunteers but there was some tendency for an insignificant decrease in AST activity. One of the volunteers had a considerable increase in AST and ALT activities 15 h after the dive, probably due to a modified diet outside the experiment conditions. Thus, the long-term simulated diving recompression treatment table did not lead to a shift in the woman's serum biochemical status. However, it remains necessary to consider probable dysfunction of liver due to hyperbaric exposure.

PMID: 16869535

7: J R Soc Interface. 2006 Feb 22;3(6):109-16.

Diving behaviour of whale sharks in relation to a predictable food pulse.

Graham RT, Roberts CM, Smart JC.
Wildlife Conservation Society, PO Box 37, Punta Gorda, Belize.
rgraham@wcs.org

We present diving data for four whale sharks in relation to a predictable food pulse (reef fish spawn) and an analysis of the longest continuous fine-resolution diving record for a planktivorous shark. Fine-resolution pressure data from a recovered pop-up archival satellite tag deployed for 206 days on a whale shark were analysed using the fast Fourier Transform method for frequency domain analysis of time-series. The results demonstrated that a free-ranging whale shark displays ultradian, diel and circa-lunar rhythmicity of diving behaviour. Whale sharks dive

to over 979.5 m and can tolerate a temperature range of 26.4 degrees C. The whale sharks made primarily diurnal deep dives and remained in relatively shallow waters at night. Whale shark diving patterns are influenced by a seasonally predictable food source, with shallower dives made during fish spawning periods.

Publication Types: Research Support, Non-U.S. Gov't
PMID: 16849222

8: Comp Biochem Physiol A Mol Integr Physiol. 2006 Sep;145(1):1-6. Epub 2006 Jun 10.

Aerobic dive limit. What is it and is it always used appropriately?

Butler PJ.

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The original definition of aerobic dive limit (ADL) was the dive duration after which there is an increase in post-dive concentration of lactate in the blood of Weddell seals freely diving in the field. The only other species in which such measurements have been made is the emperor penguin. For all other species, aerobic dive limit has been calculated (cADL) by dividing usable oxygen stores with an estimation of the rate of oxygen consumption during diving. Unfortunately, cADL is often referred to as the aerobic dive limit, implying that it is equivalent to that determined from the measurement of post-dive blood lactate concentration. However, this is not so, as at cADL all of the usable oxygen would have been consumed, whereas Weddell seals and emperor penguins can dive for at least 2-3 times longer than their ADL. Thus, at ADL, there is still some usable oxygen remaining in the stores. It is suggested that to avoid continued confusion between these two terms, the former is called diving lactate threshold (DLT), as it is somewhat analogous to the lactate threshold in exercising terrestrial vertebrates. Possible explanations of how some species routinely dive beyond their cADL are also discussed.

Publication Types: Research Support, Non-U.S. Gov't
PMID: 16846744

9: Mil Med. 2006 Jun;171(6):491-3.

Severe acute respiratory syndrome in a naval diver.

Chim H, Soo KH, Low E, Chan G.

Naval Medicine and Hyperbaric Center, Medical Service, Republic of Singapore Navy, Singapore.

Severe acute respiratory syndrome (SARS) is a highly infectious, rapidly progressive, emerging disease. Early diagnosis and preventive measures are key for treatment and minimization of secondary spread. In the context of the armed forces, aggressive containment measures are essential to prevent an outbreak. In this study, we present the first reported case, to our knowledge, of SARS in a naval diver. The special physical requirements for divers and the potential complications associated with deep sea diving necessitate extensive investigation before certification of fitness for diving after SARS. In the early recovery period, potential problems during diving are caused by inadequate lung ventilation in relation to exercise level and increased breathing resistance attributable to weak respiratory muscles, with corresponding risk of hypoxia and hypercapnia, as well as decreased ability to respond to nonrespiratory problems during diving. Problems in the late recovery period include increased risk of diving complications (such as pulmonary barotrauma) resulting from fibrosis and scarring within the lung parenchyma, which are known complications of SARS. From our experience, we suggest that computed tomographic scans of the thorax, lung function tests, and careful follow-up monitoring should play a vital role in the assessment of patients during the convalescent period, before certification of fitness to dive.

Publication Types: Case Reports
PMID: 16808126

10: Vision Res. 2006 Oct;46(20):3443-50. Epub 2006 Jun 27.

Visual training improves underwater vision in children.

Gislén A, Warrant EJ, Dacke M, Kröger RH.

Department of Cell and Organism Biology, Lund University,

Helgonavägen 3, S-223 62 Lund,
Sweden. anna.gislen@cob.lu.se

Children in a tribe of sea-gypsies from South-East Asia have been found to have superior underwater vision compared to European children. In this study, we show that the improved underwater vision of these Moken children is not due to better contrast sensitivity in general. We also show that European children can achieve the same underwater acuity as the Moken children. After 1 month of underwater training (11 sessions) followed by 4 months with no underwater activities, European children showed improved underwater vision and distinct bursts of pupil constriction. When tested 8 months after the last training session in an outdoor pool in bright sunlight-comparable to light environments in South-East Asia-the children had attained the same underwater acuity as the sea-gypsy children. The achieved performance can be explained by the combined effect of pupil constriction and strong accommodation.

Publication Types: Research Support, Non-U.S. Gov't
PMID: 16806388

11: J Comp Physiol B. 2006 Nov;176(8):739-47. Epub 2006 Jun 22. The influence of body size on the diving behaviour and physiology of the bimodally respiring turtle, *Elseya albagula*.

Mathie NJ, Franklin CE.
School of Integrative Biology, The University of Queensland, Brisbane, QLD, 4072, Australia.

In aquatic vertebrates that acquire oxygen aeriially dive durationscales positively with body mass, i.e. larger animals can dive for longer periods, however in bimodally respiring animals the relationship between dive duration and body mass is unclear. In this study we investigated the relationships between body size, aquatic respiration, and dive duration in the bimodally respiring turtle, *Elseya albagula*. Under normoxic conditions, dive duration was found to be independent of body mass. The dive durations of smaller turtles were equivalent to that of larger individuals despite their relatively smaller oxygen stores and higher mass specific metabolic rates.

Smaller turtles were able to increase their dive duration through the use of aquatic respiration. Smaller turtles had a relatively higher cloacal bursae surface area than larger turtles, which allowed them to extract a relatively larger amount of oxygen from the water. By removing the ability to respire aquatically (hypoxic conditions), the dive duration of the smaller turtles significantly decreased restoring the normal positive relationship between body size and dive duration that is seen in other air-breathing vertebrates.

Publication Types: Research Support, Non-U.S. Gov't
PMID: 16791587

12: Orthopedics. 2006 Jun;29(6):503-5.

Scaphoid stress fracture: an unusual cause of wrist pain in a competitive diver.

Hosey RG, Hauk JM, Boland MR.
Department of Family Medicine, University of Kentucky, Lexington, KY 40536, USA.

Publication Types: Case Reports
PMID: 16786942

13: Voen Med Zh. 2006 Apr;327(4):56-9.

[Age dynamics of cardiovascular system indices of divers working in small and middle depth]

[Article in Russian]

Miroshnikov EG, Miroshnikova ON, Kirillov OI.

PMID: 16784110

14: Aviat Space Environ Med. 2006 Jun;77(6):597-604.

Glutathione in blood cells decreases without DNA breaks after a simulated saturation dive to 250 msw.

Djurhuus R, Segadal K, Svardal AM.
Norwegian Underwater Intervention AS, Bergen, Norway. rdj@nui.no

INTRODUCTION: Saturation diving involves exposure to high pressure and elevated oxygen level. The impact of cellular defense systems like glutathione in protecting cells against oxidative DNA damage seems unclear. The aim of the present study was, therefore, to investigate whether diving conditions would affect blood cell glutathione and thus alter the mononuclear cells' (MNC) susceptibility to oxidative DNA damage. METHODS: Eight subjects

participated in a simulated saturation dive to 2.6 MPa (250 msw) lasting 19.3 d (0.8 d compression, 6.6 d bottom phase, 11.9 d decompression) breathing helium-oxygen with PO₂ ranging from 35 to 70 kPa (3.5-7.0 msw). Blood samples collected before compression and after decompression were analyzed for glutathione content and single-stranded DNA breaks. RESULTS: The results demonstrate for the first time that a simulated saturation dive decreased glutathione content in peripheral blood cells (32% decrease in MNC), and that the decrease was most pronounced in the erythrocytes (45%). Remarkably, no single-stranded DNA breaks could be detected in the MNC despite the low glutathione level. DISCUSSION: The results suggest that glutathione is a useful indicator of oxidative stress and that a low glutathione level represents no significant harm to the blood cells in the absence of other toxic agents. The lack of DNA strand breaks suggests that protection against oxidative DNA damage was mainly provided by mechanisms other than the glutathione system. Although previous investigations point to hyperoxia as the most plausible explanation for the present observations, the effect of high pressure cannot be excluded. Publication Types: Research Support, Non-U.S. Gov't PMID: 16780237

15: Aviat Space Environ Med. 2006 Jun;77(6):592-6.

Venous bubble count declines during strenuous exercise after an open sea dive to 30 m.

Dujić Z, Obad A, Palada I, Ivancev V, Valic Z.

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INTRODUCTION: The effect of post-dive exercise on bubble formation remains controversial, although the current practice of divers and aviators is to avoid strenuous exercise after diving. Previously, we have shown that exercising 24 h before a dive, or during a decompression stop, significantly reduces bubble formation in man. The objective of this study was to determine whether a short period of

strenuous post-dive exercise promotes venous bubble formation. METHODS: Seven male military divers performed an open-sea field dive to a maximum depth of 30 m for 30 min. At maximum depth, subjects performed mild underwater fin swimming, followed by standard decompression. Diving was followed by a post-dive exercise session consisting of short, strenuous incremental upright cycle ergometry, up to 85% of maximal oxygen uptake, for about 10 min. Subjects were monitored for venous gas bubbles in the right heart with an echo-imaging system starting 20 min post-dive while in the supine position, during cycle ergometry in the seated upright position, and immediately after exercise in a supine position. RESULTS: The average number of bubbles was 1.5 +/- 1.4 bubbles x cm⁻² 20 min after diving. Changes in posture from supine to seated upright resulted in significant reduction of bubbles to 0.6 +/- 1.3 bubbles x cm⁻² (p = 0.043), with further reduction to 0.2 +/- 0.3 bubbles x cm⁻² at the end of exercise (p = 0.02). No cases of DCS or intra-pulmonary shunt were observed during or following post-dive exercise. DISCUSSION: These results suggest that post-dive strenuous exercise after a single field dive reduces post-dive gas bubble formation in well-trained military divers. Additional findings are needed for normal sports divers. Publication Types: Research Support, Non-U.S. Gov't PMID: 16780236

16: Hawaii Med J. 2006 May;65(5):140-1, 153.

Age associated risks of recreational scuba diving.

Smerz RW.

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The effect of aging on risk for development of decompression illness in divers has often been reported as an incidental finding in epidemiological analyses of diving accidents. No previous publications have specifically attempted to quantify or qualify those risks if present. This study demonstrates

that aging increases risk for injury overall, serious injury in particular, and lessens recovery potential.

PMID: 16774142

17: Int J Sports Med. 2006 Nov;27(11):870-4. Epub 2006 Jun 8.

Pulmonary function in children after a single scuba dive.

Lemaître F, Tourny-Chollet C, Hamidouche V, Lemouton MC.

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This study evaluated the respiratory effects of a single dive in children. Eighteen young divers and 18 controls participated in our study (age range: 9 - 13 years). Volumes and expiratory flow rates were measured 20 minutes before and 10 minutes after one air dive (3 meters, 25 minutes). Before the dive, no differences were noted regarding pulmonary parameters. Ten minutes after the dive, decreases were noted in forced expiratory volume in 1 s (FEV1) and maximal voluntary ventilation (- 8 %, - 5.3 %, respectively; $p < 0.01$), peak expiratory flow, maximal expiratory flow rates at 50 % of FVC (MEF(50 %)) and MEF(25 %), forced mid-expiratory flow rate (FEF(25 - 75 %)), and FEV1/FVC(- 5.9 %, - 14.3 %, - 21.4 %, - 4.2 %, - 3.5 %, respectively; $p < 0.05$). The respiratory pattern observed 10 minutes after a single dive to three meters indicated airway narrowing. However, no association between diving experience and lung function was obtained.

PMID: 16761220

18: Int J Sports Med. 2006 Nov;27(11):875-9. Epub 2006 May 30.

Ventilatory function in experienced recreational scuba divers: Evidence of small airways disease?

Lemaître F, Tourny-Chollet C, Lemouton MC.

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Rouen, Université de Rouen, Mont-Saint-Aignan, France.

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Diving has shown long-term effects on respiratory function in trained professional divers, indicating the development of small airways disease. The results are more controversial in trained recreational divers because of the different degrees of exposure and training. The aim of this study was to investigate the effects of recreational diving on respiratory function in highly experienced divers. Volumes and expiratory flow rates were measured in 32 older recreational divers (51.6 +/- 7.4 years). The forced vital capacity (FVC) and forced expiratory volume in 1 s (FEV1) were higher (+ 4.9 % and + 6 %, respectively; $p < 0.01$) than the theoretical standards (ERS 93). These values tended to decrease more rapidly as the age advanced (age range: 43 - 73 years) ($p < 0.05$). Moreover, the mid-expiratory flows at 50 %, 25 % and 25 - 75 % of vital capacity (MEF(50 %), MEF(25 %) and MEF(25 - 75 %)) were significantly decreased. These early signs of decrease suggest slight small airways disease in older experienced recreational divers.

PMID: 16739091

19: Voen Med Zh. 2006 Mar;327(3):58-61, 96.

[Acoustic and spirometric indices of the external respiration function of divers using closed oxygenous systems]

[Article in Russian]

Pochekutova IA, Korenbaum VI, Agapov IaV.

The influence of a single diving in equipment of the closed type using respiratory gas mixture with a risen concentration of oxygen on the external respiration function of divers having small experience of underwater works is investigated by means of a tracheal forced expiratory noise analysis. 16 divers and a control group consisting of 13 men (with the age from 19 to 24 years) were inspected. Duration of tracheal forced expiratory noise was measured. Spirographic indices were registered. 10 divers were inspected in dynamics - before diving and immediately after it. T, FVC and

FEV1 changes were tested. Significant differences in T and spirographic indices among groups of divers (before diving) and the control one were not detected. On the whole after diving the only significant reduction of indices in the group of divers was connected with FEV1. Significant individual dynamics of spirographic indices was not found. 2 examined divers showed considerable increase in T reflecting bronchial patency aggravation.

Publication Types: English Abstract
PMID: 16737078

20: Int J Sports Med. 2006 Jun;27(6):508; author reply 509.

Comment on: Int J Sports Med. 2005 Oct;26(8):626-31.

Interatrial right-to-left shunting after SCUBA diving.

Boussuges A.

Publication Types: Comment Letter

PMID: 16729257

21: J Appl Physiol. 2006 Sep;101(3):866-72. Epub 2006 May 25. Increased pulmonary vascular resistance and reduced stroke volume in association with CO2 retention and inferior vena cava dilatation.

Baković D, Eterović D, Valic Z, Saratlija-Novaković Z, Palada I, Obad A, Dujić Z.

Dept. of Physiology, University of Split School of Medicine, Soltanska 2, 21000 Split, Croatia.

Changes in cardiovascular parameters elicited during a maximal breath hold are well described. However, the impact of consecutive maximal breath holds on central hemodynamics in the postapneic period is unknown. Eight trained apnea divers and eight control subjects performed five successive maximal apneas, separated by a 2-min resting interval, with face immersion in cold water. Ultrasound examinations of inferior vena cava (IVC) and the heart were carried out at times 0, 10, 20, 40, and 60 min after the last apnea. The arterial oxygen saturation level and blood pressure, heart rate, and transcutaneous partial pressures of CO(2) and O(2) were monitored continuously. At 20 min after breath holds, IVC diameter increased (27.6 and 16.8% for apnea divers and

controls, respectively). Subsequently, pulmonary vascular resistance increased and cardiac output decreased both in apnea divers (62.8 and 21.4%, respectively) and the control group (74.6 and 17.8%, respectively). Cardiac output decrements were due to reductions in stroke volumes in the presence of reduced end-diastolic ventricular volumes. Transcutaneous partial pressure of CO(2) increased in all participants during breath holding, returned to baseline between apneas, but remained slightly elevated during the postdive observation period (approximately 4.5%). Thus increased right ventricular afterload and decreased cardiac output were associated with CO(2) retention and signs of peripheralization of blood volume. These results indicate that repeated apneas may cause prolonged hemodynamic changes after resumption of normal breathing, which may suggest what happens in sleep apnea syndrome.

Publication Types: Controlled Clinical Trial Research Support, Non-U.S. Gov't
PMID: 16728515

22: Undersea Hyperb Med. 2006 Mar-Apr;33(2):135-41.

The absence of hearing loss in otologically asymptomatic recreational scuba divers.

Taylor DM, Lippmann J, Smith D.

Emergency Department, Royal Melbourne Hospital, Victoria, Australia.

We undertook a retrospective cohort study of 16 experienced recreational scuba divers and 16 matched non-diver controls to determine the prevalence of hearing loss and, if present, the likely causes of this loss. Each subject was required to be aged 55 years or less and to have no history or likelihood of hearing loss. An audiologist, blinded to each subject's group status, undertook all examinations. There were no significant differences in group demographics. All divers were highly experienced (median number of dives 725). Comparison of mean hearing thresholds (range 250-8000 Hz) revealed no significant differences between divers and non-divers for both air and bone

conduction studies. The only exception was at 6000 Hz where the air conduction threshold was significantly higher in divers than in non-divers ($p = 0.03$). However, there were no significant differences in Pure Tone and High Frequency averages. We conclude that experienced recreational scuba divers do not have elevated hearing threshold levels overall when compared to non-diver controls. This conclusion differs from that of investigators who have examined the hearing of experienced professional divers. Further investigation is indicated to further investigate this discrepancy and to determine whether the apparent hearing loss among the divers at 6000Hz was an isolated departure from normal hearing thresholds or, in fact, the result of diving.

Publication Types: Research Support, Non-U.S. Gov't
PMID: 16716064

23: Undersea Hyperb Med. 2006 Mar-Apr;33(2):125-33.

Plasma glucose response to recreational diving in novice teenage divers with insulin-requiring diabetes mellitus. Pollock NW, Uguccioni DM, Dear G, Bates S, Albushies TM, Prosterman SA.

Center for Hyperbaric Medicine and Environmental Physiology, Department of Anesthesiology, Duke University Medical Center, Durham, NC 27710, USA.

A growing number of individuals with insulin-requiring diabetes mellitus (IRDM) dive, but data on plasma glucose (PG) response to diving are limited, particularly for adolescents. We report on seven 16-17 year old novice divers with IRDM participating in a tropical diving camp who had recent at least moderate PG control (HbA1c 7.3 +/- 1.1%) (mean +/- SD). PG was measured at 60, 30 and 10 min pre-dive and immediately following 42 dives. Maximum depth (17 +/- 6 msw) and total underwater times (44 +/- 14 min) were not extreme. Pre-dive PG exceeded 16.7 mmol x L(-1) (300 mg x dL(-1)) in 22% of dives. Males had significantly higher pre-dive levels (15.4 +/- 5.6 mmol x L(-1) [277 +/- 100 mg x dL(-1)] vs. 12.8 +/- 2.9 mmol x L(-1) [230 +/- 52 mg x dL(-

1)], respectively) and greater pre-post-dive changes (-4.3 +/- 4.4 mmol x L(-1) [-78 +/- 79 mg x dL(-1)] vs. -0.5 +/- 4.3 mmol x L(-1) [-9 +/- 77 mg x dL(-1)], respectively). Post-dive PG was < 4.4 mmol x L(-1) [< 80 mg x dL(-1)] in two dives by two different males (3.4 and 3.9 mmol x L(-1) [61 and 70 mg x dL(-1)]). No symptoms or complications of hypoglycemia were reported. These data show that in a closely monitored situation, and with benign diving conditions, some diabetic adolescents with good control and no secondary complications may be able to dive safely. The impact of purposeful elevation of PG to protect against hypoglycemia during diving remains to be determined.

Publication Types: Research Support, Non-U.S. Gov't
PMID: 16716063

24: Undersea Hyperb Med. 2006 Mar-Apr;33(2):119-24.

The heart rate of breath-hold divers during static apnea: effects of competitive stress.

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Breath-hold divers compete with regard to depth, time and/or distance. The present observations were carried out on athletes performing static apnea where they perform one breath-hold for as long a duration as possible with the body and face immersed in water. Heart rate was measured on eight competitors participating in the Swedish Championship in static apnea 2001, both during the competition and during a separate training session using the Polar NV system. The duration of apneas during the competition ranged from 3 minutes 27 seconds to 5 minutes 33 seconds. The divers exhibited significantly faster heart rates prior to and during the first 90 seconds of apnea in connection with competition, than during training. One subject experienced a loss of motor control during the competition. We suggest that mental stress in humans, caused here by a competitive situation, leads to an increase in the heart rate during apnea.

Publication Types: Research
Support, Non-U.S. Gov't
PMID: 16716062

25: Undersea Hyperb Med. 2006 Mar-Apr;33(2):109-18.

Diffusing capacity and spirometry following a 60-minute dive to 4.5 meters.

Koehle MS, Hodges AN, Lynn BM, Rachich MF, McKenzie DC.

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The purpose of this study was to assess the contribution of SCUBA to the pulmonary effects of diving to 4.5 meters depth in healthy subjects using a randomized crossover control condition. Ten healthy divers performed two 60-minute 'dives' using SCUBA in a swimming pool. The non-immersed 1 ATA SCUBA control exposure took place at ambient pressure in the laboratory. Thirty minutes prior to, and 30 and 90 minutes post-exposure, FVC (forced vital capacity), FEV1.0 (forced expired volume), peak expiratory flow rate (PEFR), diffusing capacity (DL(co)), heart rate (HR) and temperature were measured. No significant differences were noted in HR, temperature or spirometry between the two conditions. A significant reduction in diffusing capacity occurred at 30 and 90 minutes after the pool dive (9.3% and 15.1%, respectively, $p < 0.05$). There was no concordant change in DL(co) following the non-immersed 1 ATA SCUBA control. Thus, a pool dive to 4.5 meters for 60 minutes causes a decrease in DL(co), without a change in spirometry, while breathing from SCUBA equipment without immersion causes no significant change in lung function. Publication Types: Randomized Controlled Trial Research Support, Non-U.S. Gov't
PMID: 16716061

26: Undersea Hyperb Med. 2006 Mar-Apr;33(2):103-8.

Post-exercise reduction in diffusing capacity of the lung after moderate intensity running and swimming.

Thorsen E, Sandsmark H, Ulltang E. Institute of Medicine, University of Bergen, Bergen, Norway.

A reduction in transfer factor of the lung for carbon monoxide (Tl(co)) is a consistent finding after saturation dives and is reported after some open sea air dives. Several diving associated factors may contribute to this reduction in Tl(co) including hyperoxia, venous gas microembolism, increased breathing resistance and immersion. Exercise, which inevitably is associated with open sea diving, may itself cause a reduction in Tl(co) up to at least 12 hours post-exercise. Six trained swimmers and six trained runners who had never dived performed 30 min moderate intensity swimming and running on different days and in random order at approximately 75% of their maximal heart rate. Lung function including a flow-volume loop and Tl(co) was measured 30 min before and 60-90 min after exercise. There were no significant changes in dynamic lung volumes or maximal expiratory flow rates, but there was a reduction in Tl(co) of 4.5 (SD = 4.8) and 4.7 (SD = 4.6) % after swimming and running respectively ($p < 0.01$). There was no difference in this response between runners and swimmers, and the response was not associated with lung size. Even moderate exercise preceding measurements of Tl(co) should generally be accounted for, and this effect may contribute significantly to lung function changes immediately after open sea dives.

Publication Types: Randomized Controlled Trial
PMID: 16716060

27: Aviat Space Environ Med. 2006 May;77(5):551-5.

Plasma glutathione peroxidase activity as a potential indicator of hypoxic stress in breath-hold diving.

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INTRODUCTION: Diving mammals can cope with oxidants which are produced in excess during the

reoxygenation of hypoxic tissues. This study addresses the question of whether antioxidants can adapt and whether it allows humans to tolerate the hypoxic stress induced by a single breath-holding in the course of a dynamic diving exercise and protect them from oxidative insult. METHODS: There were 20 male subjects who performed submaximal apnea dynamic diving (ADD). Nine control subjects stayed out of the water and breathed normally. Venous blood samples were collected 1 h before and immediately after ADD. RESULTS: ADD induced a significant increase in plasma glutathione peroxidase (GPx-3) activity (from 397.5 +/- 44.4 to 410 +/- 43 U x L(-1)), blood reduced glutathione (GSH) (from 1060 +/- 302 to 1292 +/- 213 micromol x L(-1)), and in plasma creatine kinase activity (from 215 +/- 137 to 235 +/- 152 U x L(-1)). The activity of the erythrocyte superoxide dismutase and glutathione peroxidase, as well as the blood oxidized glutathione and the plasma thiobarbituric acid reactive substances concentrations, were maintained at their basal level. The level of training, characterized by the duration and distance of the dive, had no effect on the markers used. CONCLUSION: GPx-3 and GSH could constitute the most readily mobilizable antioxidants that would then contribute to the buffering against a sudden increase in the generation of radical oxygen species. These biomarkers could be used as tools for establishing oxidative stress during hypoxia. The response of GPx-3 to hypoxia could be of physiological relevance.

Publication Types: Research Support, Non-U.S. Gov't
PMID: 16708536

28: Aviat Space Environ Med. 2006 May;77(5):526-32.

CNS toxicity in closed-circuit oxygen diving: symptoms reported from 2527 dives.

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INTRODUCTION: Oxygen toxicity is a problem in diving and can have fatal consequences in the water. Various aspects of oxygen diving have been studied in dry hyperbaric chambers,

but there is a lack of information on in-water diving using closed-circuit oxygen apparatus. METHOD: We collected 2527 dive reports from 473 closed-circuit oxygen divers (a mean of 5.2 reports per diver), and analyzed the relationships between various symptoms and their dependence on depth and diving time. RESULTS: No CNS oxygen toxicity-related symptoms were reported at a depth of 2 m seawater (msw), but their proportion increased at depths from 3 to 6 msw. We found that CNS oxygen toxicity-related symptoms appeared in 2.5% of dives conducted at a Po₂ of 119 kPa. The main symptoms and signs reported were headache: 4.5%; nausea: 2.6%; hyperventilation: 2.6%; heavy breathing: 2.4%; dizziness: 1.6%; hiccups: 1.5%; bloody sputum: 1.4%; cold shivering: 1.1%; tinnitus: 0.9%; difficulty maintaining a steady depth: 0.9%; disorientation: 0.6%; tiredness: 0.5%; tingling in the limbs: 0.4%; hearing disturbances: 0.4%; a choking sensation: 0.4%; extreme effort: 0.4%; and loss of consciousness: 0.3%. DISCUSSION: Environmental factors, light vs. dark and temperature, had no effect on symptoms. The number of symptoms increased with diving time. Divers who experienced amnesia, facial twitching, hearing disturbances ($p < 0.001$), and disorientation ($p < 0.014$) were prone to suffer loss of consciousness. It was found that some divers are more sensitive to oxygen than others ($p < 0.0001$).

PMID: 16708533

29: Eur J Appl Physiol. 2006 Jul;97(4):478-85. Epub 2006 May 13.

A single open sea air dive increases pulmonary artery pressure and reduces right ventricular function in professional divers.

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After decompression from dives, bubbles are frequently observed in the right ventricular outflow tract and may lead to vascular damage, pulmonary arterial hypertension and right ventricular overload. No data exist on the effect of open sea

diving on the pulmonary artery pressure (PAP). Eight professional divers performed an open sea air dive to 30 msw. Before and postdive a Doppler echocardiographic study was undertaken. Systolic pulmonary artery pressure (SPAP) was estimated from measurement of peak flow velocity of the tricuspid regurgitant jet; the ratio between pulmonary artery acceleration times (AccT) and right ventricular ejection time (RVET) was used as an estimate of the mean PAP. No evidence of either patent foramen ovale or intra-pulmonary shunt was found in any subject postdive after performing a Valsalva maneuver. SPAP increased from 25 +/- 3 to 33 +/- 2 mmHg and AccT/RVET ratio decreased from 0.44 +/- 0.04 to 0.3 +/- 0.02 20 min after the dive, respectively. Pulmonary vascular resistance increased from 1.2 +/- 0.1 to 1.4 +/- 0.1 Woods Units. Postdive right ventricle end-diastolic and end-systolic volumes were increased for about 19% (P = 0.001) and 33% (P = 0.001) and right ejection fraction decreased about for 6% (P = 0.001). Cardiac output decreased from 4.8 +/- 0.9 (l min(-1)) to 4.0 +/- 0.6 at 40 min postdive due to decreases in heart rate and stroke volume. This study shows that a single open sea dive may be associated with right heart overload due to increased pressure in the pulmonary artery.

Publication Types: Comparative Study
Research Support, Non-U.S. Gov't
PMID: 16708239

30: J Obstet Gynaecol. 2006 Apr;26(3):216-21.

Problems associated with scuba diving are not evenly distributed across a menstrual cycle.

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The problems encountered during scuba diving may be a contributing factor in an episode of decompression illness (DCI). Evidence exists that there may be a relationship between the position in the menstrual cycle and the occurrence of DCI. We examined, by

prospective observation in female recreational scuba divers, any interaction between reported problems during diving (RPDD) and the position in the menstrual cycle. A total of 533 women, aged between 14 and 57 years, returned diaries for >6 months, with 61% returning diaries for 3 consecutive years. A total of 34,625 dives were reported within 11,461 menstrual cycles between 21 and 40 days in length, with 65% of women reporting at least one RPDD. Logistic regression showed a significant non-linear relationship between the position in the menstrual cycle and RPDD (p = 0.004). RPDD were not evenly distributed over the menstrual cycle; the rate per 1,000 dives varied from 39.2 at start of the cycle to 19.7 during week 3, and 31.9 in week 4. We concluded these field data suggest a possible correlation between the incidence of RPDD and the position in which they occurred in the menstrual cycle.

Publication Types: Research Support, Non-U.S. Gov't
PMID: 16698628

31: J Appl Physiol. 2006 Sep;101(3):799-801. Epub 2006 May 11.

Features of glossopharyngeal breathing in breath-hold divers.

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One technique employed by competitive breath-hold divers to increase diving depth is to hyperinflate the lungs with glossopharyngeal breathing (GPB). Our aim was to assess the relationship between measured volume and pressure changes due to GPB. Seven healthy male breath-hold divers, age 33 (8) [mean (SD)] years were recruited. Subjects performed baseline body plethysmography (TLC(PRE)). Plethysmography and mouth relaxation pressure were recorded immediately following a maximal GPB maneuver at total lung capacity (TLC) (TLC(GPB)) and within 5 min after the final GPB maneuver (TLC(POST)). Mean TLC increased from TLC(PRE) to TLC(GPB) by 1.95 (0.66) liters and vital capacity (VC) by

1.92 (0.56) liters ($P < 0.0001$), with no change in residual volume. There was an increase in TLC(POST) compared with TLC(PRE) of 0.16 liters (0.14) ($P < 0.02$). Mean mouth relaxation pressure at TLC(GPB) was 65 (19) cmH₂O and was highly correlated with the percent increase in TLC ($R = 0.96$). Breath-hold divers achieve substantial increases in measured lung volumes using GPB primarily from increasing VC. Approximately one-third of the additional air was accommodated by air compression.

Publication Types: Clinical Trial
PMID: 16690794

32: J Anim Ecol. 2006 May;75(3):814-25.

Deep-diving foraging behaviour of sperm whales (*Physeter macrocephalus*).

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1. Digital tags were used to describe diving and vocal behaviour of sperm whales during 198 complete and partial foraging dives made by 37 individual sperm whales in the Atlantic Ocean, the Gulf of Mexico and the Ligurian Sea. 2. The maximum depth of dive averaged by individual differed across the three regions and was 985 m (SD = 124.3), 644 m (123.4) and 827 m (60.3), respectively. An average dive cycle consisted of a 45 min (6.3) dive with a 9 min (3.0) surface interval, with no significant differences among regions. On average, whales spent greater than 72% of their time in foraging dive cycles. 3. Whales produced regular clicks for 81% (4.1) of a dive and 64% (14.6) of the descent phase. The occurrence of buzz vocalizations (also called 'creaks') as an indicator of the foraging phase of a dive showed no difference in mean prey capture attempts per dive between regions [18 buzzes/dive (7.6)]. Sperm whales descended a mean of 392 m (144) from the start of regular clicking to the first buzz, which supports the hypothesis that regular clicks function as a long-range biosonar. 4. There were no significant

differences in the duration of the foraging phase [28 min (6.0)] or percentage of the dive duration in the foraging phase [62% (7.3)] between the three regions, with an overall average proportion of time spent actively encountering prey during dive cycles of 0.53 (0.05). Whales maintained their time in the foraging phase by decreasing transit time for deeper foraging dives. 5. Similarity in foraging behaviour in the three regions and high diving efficiencies suggest that the success of sperm whales as mesopelagic predators is due in part to long-range echolocation of deep prey patches, efficient locomotion and a large aerobic capacity during diving.

Publication Types: Research Support, Non-U.S. Gov't
Research Support, U.S. Gov't, Non-P.H.S.
PMID: 16689963

33: Nature. 2006 May 11;441(7090):171.

Diving insects boost their buoyancy bubbles.

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Backswimmers (Notonectidae) are common diving insects found around the world that exploit the mid-water zone for predation--they breathe by using an air bubble collected at the surface. Here we show that backswimmers achieve prolonged periods of neutral buoyancy by using oxygen stored in their haemoglobin to stabilize the volume of the bubble as they breathe from it. This enables them to maintain their position in the water column without continually swimming.

PMID: 16688167

34: J Trauma. 2006 May;60(5):1041-6.
Risk factors for water sports-related cervical spine injuries.

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BACKGROUND: To examine risk factors associated with water sports-related cervical spine injuries (WCSOI). METHODS: A retrospective analysis of all patients admitted for WCSOI from 1993 to 1997 was performed. The

severity of cervical spine injury was assessed by review of medical records and imaging studies. Mechanisms of injury and activities at the time of injury were noted to determine risk factors for cervical spine injuries caused by wave forced impacts (WFI) from activities such as bodysurfing and body boarding. These risks were compared with injuries incurred by shallow water dives (SWD). RESULTS: One hundred patients were analyzed (mean age, 36 years old); 89% were male, 62% were nonresidents of Hawaii, and 75% had a large build. Patients without radiographic evidence of fractures, subluxations, and/or dislocations (n = 26) were significantly older (48 versus 32 years old, $p < 0.0001$) with a higher rate of pre-existing cervical spine abnormalities (65% versus 15%, $p < 0.0001$) compared with the remainder of patients (n = 74). Seventy-seven percent of WFI involved nonresidents. The mean age of WFI patients was significantly older than patients involved in SWD (42 versus 25 years). Ninety-six percent of wave-related accidents occurred at moderately to severely rated shorebreak beaches. CONCLUSIONS: Wave forced impacts of the head with the ocean bottom typically occurred at moderate to severe shorebreaks, and involved inexperienced, large-build males in their 40s. Spinal stenosis and degenerative spondylosis may increase the risk of cervical spine injury associated with WFI due to the increased risk of neck hyperextension and hyperflexion impacts inherent to this activity. PMID: 16688068

35: Chest. 2006 May;129(5):1337-43. Hemodynamic changes induced by recreational scuba diving. Boussuges A, Blanc F, Carturan D. IMNSSA, B.P.610, 83800 Toulon, France. alainboussuges@libertysurf.fr OBJECTIVE: Cardiac changes induced by scuba diving were investigated using Doppler echocardiography. MATERIAL AND METHODS: Ten healthy scuba divers dove to a mean depth of 34.3 +/- 2.7 m of sea water (113 +/- 9 feet) and a mean duration of 25.3 +/- 3.5 min. RESULTS: One hour after the dive, microbubbles could be detected in the right-heart

chambers of all subjects. Left atrial and left ventricular (LV) diameters significantly decreased after the dive. Cardiac output, assessed by aortic blood flow, remained unchanged. Heart rate increased and stroke volume (SV) decreased after the dive. LV filling was assessed on transmitral profile. An increase of the contribution of the atrial contraction to LV filling was observed. Right cavity diameters were unchanged, but an increase of the right ventricular/right atrial gradient pressure was found. CONCLUSION: The diving profile studied promotes a rather important bubble grade in all volunteers. A significantly reduced cardiac diameters and SV was found by our hemodynamic study 1 h after diving. Two factors can explain these results: low volemia secondary to immersion, and venous gas embolism induced by nitrogen desaturation. Consequently, restoration of the water balance of the body should be considered in the recovery process after diving.

Publication Types: Comparative Study
PMID: 16685027

36: JEMS. 2006 Apr;31(4):80-4, 86, 88-91; quiz 94-5. Under pressure. Responding to scuba emergencies. Haddox R. Simmons Ambulance Service, Monroe County, Ala, USA. PMID: 16676445

37: Environ Health Perspect. 2006 May;114(5):712-7. A survey of diving behaviour and accidental water ingestion among Dutch occupational and sport divers to assess the risk of infection with waterborne pathogenic microorganisms. Schijven J, de Roda Husman AM. Microbiological Laboratory for Health Protection, National Institute of Public Health and the Environment, Bilthoven, the Netherlands. jack.schijven@rivm.nl Divers may run a higher risk of infection with waterborne pathogens than bathers because of more frequent and intense contact with water that may not comply with microbiologic water quality standards for bathing water. In this

study we aimed to estimate the volume of water swallowed during diving as a key factor for infection risk assessment associated with diving. Using questionnaires, occupational and sport divers in the Netherlands were asked about number of dives, volume of swallowed water, and health complaints (nausea, vomiting, diarrhea, and ear, skin, eye, and respiratory complaints). Occupational divers, on average, swallowed 9.8 mL marine water and 5.7 mL fresh surface water per dive. Sport divers swallowed, on average, 9.0 mL marine water; 13 mL fresh recreational water; 3.2 mL river, canal, or city canal water; and 20 mL water in circulation pools. Divers swallowed less water when wearing a full face mask instead of an ordinary diving mask and even less when wearing a diving helmet. A full face mask or a diving helmet is recommended when diving in fecally contaminated water. From the volumes of swallowed water and concentrations of pathogens in fecally contaminated water, we estimated the infection risks per dive and per year to be as high as a few to up to tens of percents. This may explain why only 20% of the divers reported having none of the inquired health complaints within a period of 1 year. It is highly recommended that divers be informed about fecal contamination of the diving water.

Publication Types: Research Support, Non-U.S. Gov't
PMID: 16675425

38: Am Nat. 2006 Feb;167(2):276-87. Epub 2006 Jan 9.

A phylogenetic analysis of the allometry of diving.
Halsey LG, Butler PJ, Blackburn TM. Centre for Ornithology, School of Biosciences, University of Birmingham, Edgbaston, Birmingham B15 2TT, United Kingdom. l.g.halsey@bham.ac.uk

The oxygen store/usage hypothesis suggests that larger animals are able to dive for longer and hence deeper because oxygen storage scales isometrically with body mass, whereas oxygen usage scales allometrically with an exponent <1 (typically 0.67-0.75). Previous tests of the allometry of diving tend to reject this hypothesis, but

they are based on restricted data sets or invalid statistical analyses (which assume that every species provides independent information). Here we apply information-theoretic statistical methods that are phylogenetically informed to a large data set on diving variables for birds and mammals to describe the allometry of diving. Body mass is strongly related to all dive variables except dive:pause ratio. We demonstrate that many diving variables covary strongly with body mass and that they have allometric exponents close to 0.33. Thus, our results fail to falsify the oxygen store/usage hypothesis. The allometric relationships for most diving variables are statistically indistinguishable for birds and mammals, but birds tend to dive deeper than mammals of equivalent mass. The allometric relationships for all diving variables except mean dive duration are also statistically indistinguishable for all major taxonomic groups of divers within birds and mammals, with the exception of the procellariiforms, which, strictly speaking, are not true divers.

Publication Types: Comparative Study
Research Support, Non-U.S. Gov't
PMID: 16670986

39: J Anim Ecol. 2006 Mar;75(2):408-20.

Stomach temperature telemetry reveals temporal patterns of foraging success in a free-ranging marine mammal.

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1. We studied feeding frequency in free-ranging grey seals using stomach temperature telemetry to test if previously reported sex differences in the diving, movement and diet were reflected in the temporal pattern of foraging success. 2. Data were retrieved from 21 of 32 grey seals from 1999 to 2001, totalling 343 days and 555 feeding events, with individual record length varying from 2 to 40 days (mean: 16.33 +/- 2.67 days/seal). 3. Seals fed on 57.8 +/- 6.46% of days sampled and had an

average of 1.7 +/- 0.26 meals per day, but individual variability was apparent in the temporal distribution of feeding as evidenced by high coefficients of variation (coefficient of variation = 69.0%). 4. Bout analysis of non-feeding intervals of six grey seals suggests that feeding intervals of individuals were varied and probably reflect differences in prey availability. Grey seals tended to have many single feeding events with long periods separating each event, as would be expected for a large carnivore with a batch-reactor digestive system. 5. We found significant sex differences in the temporal distribution of feeding. The number of feeding events per day was greater in males (2.2 +/- 0.4 vs. 1.0 +/- 0.2), as was time associated with feeding per day (56.6 +/- 5.8 min vs. 43.9 +/- 9.4 min). 6. The number of feeding events varied with time of day with the least number occurring during dawn. Feeding event size differed significantly by time of day, with greater meal sizes during the dawn and the smallest meals during the night. 7. The length of time between meals increased with the size of the previous meal, and was significantly less in males (541.4 +/- 63.5 min) than in females (1092.6 +/- 169.9 min). 8. These results provide new insight into the basis of sex differences in diving and diet in this large size-dimorphic marine predator.

Publication Types: Comparative Study
Research Support, Non-U.S. Gov't
PMID: 16637994

40: J Anim Ecol. 2006 Mar;75(2):358-67.

Ontogeny of diving behaviour in the Australian sea lion: trials of adolescence in a late bloomer.

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1. Foraging behaviours of the Australian sea lion (*Neophoca cinerea*) reflect an animal working hard to exploit benthic habitats. Lactating females demonstrate almost continuous diving, maximize bottom

time, exhibit elevated field metabolism and frequently exceed their calculated aerobic dive limit. Given that larger animals have disproportionately greater diving capabilities, we wanted to examine how pups and juveniles forage successfully. 2. Time/depth recorders were deployed on pups, juveniles and adult females at Seal Bay Conservation Park, Kangaroo Island, South Australia. Ten different mother/pup pairs were equipped at three stages of development (6, 15 and 23 months) to record the diving behaviours of 51 (nine instruments failed) animals. 3. Dive depth and duration increased with age. However, development was slow. At 6 months, pups demonstrated minimal diving activity and the mean depth for 23-month-old juveniles was only 44 +/- 4 m, or 62% of adult mean depth. 4. Although pups and juveniles did not reach adult depths or durations, dive records for young sea lions indicate benthic diving with mean bottom times (2.0 +/- 0.2 min) similar to those of females (2.1 +/- 0.2 min). This was accomplished by spending higher proportions of each dive and total time at sea on or near the bottom than adults. Immature sea lions also spent a higher percentage of time at sea diving. 5. Juveniles may have to work harder because they are weaned before reaching full diving capability. For benthic foragers, reduced diving ability limits available foraging habitat. Furthermore, as juveniles appear to operate close to their physiological maximum, they would have a difficult time increasing foraging effort in response to reductions in prey. Although benthic prey are less influenced by seasonal fluctuations and oceanographic perturbations than epipelagic prey, demersal fishery trawls may impact juvenile survival by disrupting habitat and removing larger size classes of prey. These issues may be an important factor as to why the Australian sea lion population is currently at risk.

Publication Types: Research Support, Non-U.S. Gov't
Research Support, U.S. Gov't, Non-P.H.S.
PMID: 16637989

41: Joint Bone Spine. 2006 Jul;73(4):419-23. Epub 2006 Mar 20.

Effects of breath-hold diving on bone mineral density of women divers.

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OBJECTIVES: The relationship between bone mineral density (BMD) and swimming has been thoroughly researched. The aim of this study was to determine the effects of breath-hold diving on the BMD in the proximal femurs of women divers.

METHODS: A case-control observational study was carried out using health-checks of divers and control subjects at a hospital in Jeju City, South Korea. Women divers (N=61) were matched individually with non-diver controls (N=61) by age, weight, and postmenopausal year. The bone mineral densities of their proximal femurs (total hip, femoral neck) were assessed by dual-energy X-ray absorptiometry.

RESULTS: The average diving year of women divers was 34+/-13 years. The BMD of divers was higher than that of controls in the total hip and femur neck area (P<0.05). On multiple linear regression analysis, age and body weight were predictors of proximal femur bone mineral densities in divers. On linear regression analysis of the proximal femur BMD according to age in divers and controls, the bone mineral densities of divers tend to decrease more rapidly than those of controls in all two areas of the proximal femurs. **CONCLUSIONS:** Our study results may suggest that diving in a high-pressure environment is an osteogenic stimulus. However, the weight-supported environment in diving exerts an effect that reduces BMD proportionately to the time spent in the water.

Publication Types: Research Support, Non-U.S. Gov't
PMID: 16626996

42: Comp Biochem Physiol A Mol Integr Physiol. 2006 Jun;144(2):232-41. Epub 2006 Apr 19.

Body cooling and the diving capabilities of muskrats (*Ondatra zibethicus*): a test of the adaptive hypothermia hypothesis.

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We tested the hypothesis that immersion hypothermia enhances the diving capabilities of adult and juvenile muskrats by reducing rates of oxygen consumption (V O₂). Declines in abdominal body temperature (T(b)) comparable to those observed in nature (0.5-3.5 degrees C) were induced by pre-chilling animals in 6 degrees C water. Pre-chilling did not reduce diving V O₂ of any animal tested in 10 degrees C or 30 degrees C water, irrespective of the nature of the dive. Most behavioural indices of dive performance, including average and cumulative dive times, were unaffected by T(b) reduction in adults, but depressed in hypothermic juveniles (200-400 g). Hypothermia reduced diving heart rate only on short (<25s) dives (16% reduction, P=0.01), but did not affect the temporal onset of diving bradycardia. Post-immersion V O₂ was higher for pre-chilled than for normothermic muskrats, but the difference became insignificant on longer (>90 s) dives. Our findings suggest that the mild hypothermia experienced by muskrats in nature has minimal effect on diving and post-immersion metabolic costs, and thus has little impact on the dive performance of this northern semi-aquatic mammal.

Publication Types: Comparative Study
Research Support, Non-U.S. Gov't
PMID: 16626985

43: Hawaii Med J. 2006 Feb;65(2):53-4.

Medical school hotline.

Smerm RW, Farm F Jr.

The Hyperbaric Treatment Center John A. Burns School of Medicine, USA.

PMID: 16619862

44: Hong Kong Med J. 2006 Apr;12(2):152-3.

Spontaneous pneumomediastinum in a scuba diver.

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Pneumomediastinum usually occurs following an airleak from the lungs, or from a perforated oesophagus. We report on a 30-year-old man who developed pneumomediastinum after scuba diving. The patient presented with acute onset of throat pain, odynophagia, and hoarseness of voice. The literature is reviewed for this condition.

Publication Types: Case Reports
PMID: 16603784

45: Undersea Hyperb Med. 2006 Jan-Feb;33(1):63-8.

Effects of 30-m nitrox saturation dive on the immune system in man.

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Center for Life Science Research, University of Yamanashi, 1110 Shimokato, Tamaho, Yamanashi, Japan. Hyperbaria reportedly affects the immune system, but the role of psychological factors arising from confinement has not been taken into consideration. We investigated the immune changes in 4 subjects exposed to a 9-day simulated 30-m (400-kPa) nitrogen-oxygen (nitrox) saturation dive, and compared the results with those of our previous study that showed immune and mood changes in normobaric confinement. Blood samples were taken before, during, and after the dive or confinement, and activated with an anti-CD2 agonistic antibody. The percentages of granulocytes, natural killer (NK) cells, and cells positive for CD69, an early activation marker, were analyzed by flow cytometry. Reduction of CD69 expression percentage was observed under both hyperbaric and normobaric conditions. Percentages of innate immune cells, such as granulocytes and NK cells decreased or remained mostly unchanged, contrasting with our previous study, which demonstrated increases in both percentages coordinate with mood improvement. We conclude that these changes may have been triggered by suppression of sympathetic nerve activity that occurs in 30-m nitrox saturation hyperbaria.

PMID: 16602258

46: Undersea Hyperb Med. 2006 Jan-Feb;33(1):55-62.

Adverse events in competitive breath-hold diving.

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Medical observations are reported from an eight-day world championship breath-hold diving competition involving 57 participants. The deepest dive was to 75 metres, and the longest breath-hold time exceeded 9 minutes. There were 35 diving-related adverse events witnessed or reported, including transient loss of motor control due to hypoxia, syncope during ascent, hemoptysis, and pulmonary edema. All events occurred in healthy individuals, and resolved without apparent sequelae. There was no relationship between symptoms and depth. The medical implications of these adverse events are discussed. Despite the inherent risks of the sport, established organizational procedures for competitive breath-hold diving maintain a high degree of safety.

PMID: 16602257

47: Undersea Hyperb Med. 2006 Jan-Feb;33(1):45-53.

Validity of cycle test in air compared to underwater cycling.

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According to international guidelines, fitness to dive is generally assessed using a bicycle stress test (BST) in air. To date, there is no study explicitly addressing the question whether the results of a BST in air really predict performance status under water. Therefore, the aim of the present study was twofold: first, to design an experimental setting allowing the examination of physical performance status under water, and second, to examine whether there is an association of response to exercise in air compared to exercise under water using self contained underwater breathing apparatus (SCUBA). We constructed and evaluated a measurement technique for a bicycle ergometry and for gas analysis under water. Part of the work was the development of a new valve system which allowed to collect the exhaled air in total and

to transport it to the spirometer next to the pool. Twenty-eight healthy male divers underwent a BST. Compared to a given workload in air, gross capacity decreased significantly by about 50% underwater. High performance in air was associated with a high performance underwater. The examinations were carried out without any complications. In conclusion, our experimental setting allowed the safe and reliable examination of physical performance status under water. First results indicate that the results of a BST in air correlate well with the cardio-circulatory performance status underwater. A subsequent study with a larger sample size will enable us to more precisely model this correlation.

Publication Types: Comparative Study
PMID: 16602256

48: Undersea Hyperb Med. 2006 Jan-Feb;33(1):5-10.

Clinical observation: Beau's lines on fingernails after deep saturation dives.

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Transverse furrows, or Beau's lines, were noted in the fingernails of all 6 divers following a deep saturation dive to a pressure equal to 1100 feet (335 meters) of sea water (3,370 kPa), and in 2 of 6 divers following a similar dive to 1000 feet (305 meters) of sea water (3,164 kPa). Both dives took place at the Ocean Simulation Facility of the Navy Experimental Diving Unit in Panama City, Florida. The divers breathed a partial pressure of 0.40 - 0.44 atm abs (40.5 - 44.6 kPa) oxygen, with the balance helium, during most of the time under pressure. All divers performed hard work on bicycle ergometers during the dives. Four of the divers on the first dive were treated during the dive for pain-only decompression sickness. Beau's lines have been reported in numerous medical conditions such as typhus, rheumatic fever, malaria, myocardial infarction, and other severe metabolic stresses. To the author's knowledge this is the first report

of Beau's lines associated with saturation diving.

Publication Types: Research Support, U.S. Gov't, Non-P.H.S.
PMID: 16602251

49: Pathol Biol (Paris). 2006 Apr;54(3):155-8.

[Thrombophilic factors in divers with undeserved decompression sickness]

[Article in French]

Candito M, Chatel M, Candito E, Lapoussiere M, Mengual R, Van Obberghen E, Dunac A.

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In divers with a vascular disease in decompression sickness, who have not committed any technical error, thrombophilic risk factors were sought. Six cases of confirmed divers, without diving technical error, were investigated. Thrombophilic screening included proteins C, S, antithrombin III, and factor VIII assays, and circulating antibodies, Factor V Leiden, and mutation G20210A mutation in Factor II gene research. Total plasma homocysteine (Hcy), an atherosclerosis factor, even when slightly increased, nutritional factors: folate and vitamins B12 and B6, the cofactors of its metabolism, and inversely correlated with Hcy values, were assayed, and subjects were genotyped for mutation C677T in the MTHFR gene. RESULTS: In five divers, Hcy values were moderately increased, and in all the six, folate and/or B12 values were decreased. Three of them showed a genotype TT (mutation C677T), two, the genotype CT, and the sixth, an heterozygous Factor V Leiden. In these divers, a predisposition for vascular diseases, was detected, which was partially curable.

Publication Types: Case Reports
English Abstract
PMID: 16574534

50: J Exp Biol. 2006 Apr;209(Pt 7):1231-44.

Kinematics of foraging dives and lunge-feeding in fin whales.

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Fin whales are among the largest predators on earth, yet little is known about their foraging behavior at depth. These whales obtain their prey by lunge-feeding, an extraordinary biomechanical event where large amounts of water and prey are engulfed and filtered. This process entails a high energetic cost that effectively decreases dive duration and increases post-dive recovery time. To examine the body mechanics of fin whales during foraging dives we attached high-resolution digital tags, equipped with a hydrophone, a depth gauge and a dual-axis accelerometer, to the backs of surfacing fin whales in the Southern California Bight. Body pitch and roll were estimated by changes in static gravitational acceleration detected by orthogonal axes of the accelerometer, while higher frequency, smaller amplitude oscillations in the accelerometer signals were interpreted as bouts of active fluking. Instantaneous velocity of the whale was determined from the magnitude of turbulent flow noise measured by the hydrophone and confirmed by kinematic analysis. Fin whales employed gliding gaits during descent, executed a series of lunges at depth and ascended to the surface by steady fluking. Our examination of body kinematics at depth reveals variable lunge-feeding behavior in the context of distinct kinematic modes, which exhibit temporal coordination of rotational torques with translational accelerations. Maximum swimming speeds during lunges match previous estimates of the flow-induced pressure needed to completely expand the buccal cavity during feeding.

Publication Types: Research Support, Non-U.S. Gov't Research Support, U.S. Gov't, Non-P.H.S.
PMID: 16547295

51: J Exp Biol. 2006 Apr;209(Pt 7):1217-30.

Swim speeds and stroke patterns in wing-propelled divers: a comparison among alcids and a penguin.

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In diving birds, the volume and resulting buoyancy of air spaces changes with dive depth, and hydrodynamic drag varies with swim speed. These factors are important in the dive patterns and locomotion of alcids that use their wings both for aerial flight and underwater swimming and of penguins that use their wings only for swimming. Using small data-loggers on free-ranging birds diving to 20-30 m depth, we measured depth at 1 Hz and surge and heave accelerations at 32-64 Hz of four species of alcids (0.6-1.0 kg mass) and the smallest penguin species (1.2 kg). Low- and high-frequency components of the fluctuation of acceleration yielded estimates of body angles and stroke frequencies, respectively. Swim speed was estimated from body angle and rate of depth change. Brünnich's (*Uria lomvia*) and common (*Uria aalge*) guillemots descended almost vertically, whereas descent of razorbills (*Alca torda*), rhinoceros auklets (*Cerorhinca monocerata*) and little penguins (*Eudyptula minor*) was more oblique. For all species, swim speed during descent was within a relatively narrow range. Above depths of 20-30 m, where they were all positively buoyant, all species ascended without wing stroking. During descent, little penguins made forward accelerations on both the upstroke and downstroke regardless of dive depth. By contrast, descending alcids produced forward accelerations on both upstroke and downstroke at depths of <10 m but mainly on the downstroke at greater depths; this change seemed to correspond to the decrease of buoyancy with increasing depth. The magnitude of surge (forward) acceleration during downstrokes was smaller, and that during upstrokes greater, in little penguins than in alcids. This pattern presumably reflected the proportionally greater mass of upstroke muscles in penguins compared with alcids and may allow

little penguins to swim at less variable instantaneous speeds.

Publication Types: Comparative Study
Research Support, Non-U.S. Gov't
Research Support, U.S. Gov't, Non-P.H.S.
PMID: 16547294

52: Mil Med. 2006 Jan;171(1):ii.
Comment on: Mil Med. 2005 Jan;170(1):57-62.
The role of radiology in dive-related disorders.
Yildiz S, Uzun G.
Publication Types: Comment Letter
PMID: 16532864

53: Orbit. 2006 Mar;25(1):19-22.
Orbital subperiosteal hemorrhage while scuba diving.
Gómez-Ledesma I, Mencia-Gutiérrez E, Gutiérrez-Díaz E, Alonso-Santiago MA.

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PURPOSE: To report an uncommon case of unilateral subperiosteal hemorrhage while scuba diving involving the orbit, a condition characterized by proptosis and associated severe ocular motility disturbances with displacement of the eyeball. MATERIAL AND METHODS: Observational case report. RESULTS: Unilateral subperiosteal hemorrhage in a 31-year-old woman while scuba diving at a depth of 20 meters. This was documented by clinical and radiographic examination. Computed tomography (CT) scan demonstrated a subperiosteal hemorrhage as a self-limited mass protruding into the left orbit. The process resolved without treatment and without visual or motility sequelae. A CT-scan, nuclear magnetic resonance, and conventional angiography did not show any venous abnormalities in the brain. CONCLUSION: During scuba diving at a depth of 20 meters, the pressure is three atmospheres, whereas within the diving mask the pressure is one atmosphere if it is not equilibrated; thus, a negative pressure is created within the mask. Small vessels can be broken in the conjunctiva or subperiosteal space by this force. It is important to exclude vascular abnormalities, especially if there is a positive family history.

Publication Types: Case Reports
PMID: 16527770

54: Eur J Appl Physiol. 2006 May;97(2):158-64. Epub 2006 Mar 9.
Influence of lung volume, glossopharyngeal inhalation and P(ET) O₂ and P(ET) CO₂ on apnea performance in trained breath-hold divers.

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Breath-hold divers train and compete in maximal apnea performance. Glossopharyngeal inhalation (GI) is commonly used to increase lung volume above vital capacity (VC) prior to apnea. We investigated the hypothesis that this practice would increase apnea performance and relaxed airway pressure. Seven well-trained breath-hold divers performed maximal bouts of apnea at three different lung volumes (85% VC, VC and VC + GI) both at rest (dry static apnea) and during underwater swimming (dynamic apnea). Heart rate, apnea time and end tidal PCO₂ and PO₂ (P(ET) CO₂ and P(ET) O₂) were recorded. In addition, relaxed airway pressure was measured after GI. Maximal GI increased lung volume by 1.59±0.57 l above VC and increased relaxed airway pressure to from 3.5±0.5 to 8.7±1.7 kPa. Dry static apnea time was higher at VC + GI (346±46 s) than at VC (309±38 s, P<0.05) and 85% VC (297±48 s, P<0.01). Likewise, dynamic apnea time was higher at VC + GI (97±27 s) than at VC (78±14 s, P<0.05) and 85% VC (71±17 s, P<0.05). P(ET) O₂ values reached 3.5±0.6 kPa at the end of dry static apnea bouts and this was not different from dynamic apnea when taking hydrostatic pressure at swimming depth into account (3.7±0.6 kPa, P=0.48). In conclusion, GI increases lung volume, relaxed airway pressure and apnea performance in well-trained breath-hold divers.

Publication Types: Research Support, Non-U.S. Gov't
PMID: 16525813

55: J Comp Physiol B. 2006 Aug;176(6):535-45. Epub 2006 Mar 3.

Ontogeny of total body oxygen stores and aerobic dive potential in Steller sea lions (*Eumetopias jubatus*).

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Two key factors influence the diving and hence foraging ability of marine mammals: increased oxygen stores prolong aerobic metabolism and decreased metabolism slows rate of fuel consumption. In young animals, foraging ability may be physiologically limited due to low total body oxygen stores and high mass specific metabolic rates. To examine the development of dive physiology in Steller sea lions, total body oxygen stores were measured in animals from 1 to 29 months of age and used to estimate aerobic dive limit (ADL). Blood oxygen stores were determined by measuring hematocrit, hemoglobin, and plasma volume, while muscle oxygen stores were determined by measuring myoglobin concentration and total muscle mass. Around 2 years of age, juveniles attained mass specific total body oxygen stores that were similar to those of adult females; however, their estimated ADL remained less than that of adults, most likely due to their smaller size and higher mass specific metabolic rates. These findings indicate that juvenile Steller sea lion oxygen stores remain immature for more than a year, and therefore may constrain dive behavior during the transition to nutritional independence.

Publication Types: Research Support, Non-U.S. Gov't
PMID: 16514541

56: Intern Med J. 2006 Mar;36(3):193-6.

A case of type 3 DCS with a radiologically normal spinal cord.
Gorman D, Sames C, Drewry A, Bodicoat S.

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A subtype of cerebral arterial gas embolism arising in divers, in which apparent spinal cord disease follows early cerebral manifestations, is well known and

has been described as type 3 DCS. A case that clinically conformed to the pattern of type 3 DCS was examined radiologically. Despite clinical signs of spinal disease, magnetic resonance imaging scans of the spinal cord did not demonstrate pathology.

Publication Types: Case Reports
PMID: 16503955

57: Aviat Space Environ Med. 2006 Feb;77(2):102-6.

Dehydration effects on the risk of severe decompression sickness in a swine model.

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BACKGROUND: Several physiological factors have been suspected of affecting the risk of decompression sickness (DCS), but few have been thoroughly studied during controlled conditions. Dehydration is a potential factor that could increase the risk of DCS. It has been suggested that hydration may enhance inert gas removal or increase surface tension of the blood. HYPOTHESIS: Dehydration increases DCS risk. METHODS: Littermate pairs of male Yorkshire swine (n=57, mean +/- 1 SD 20.6 +/- 1.7 kg) were randomized into two groups. The hydrated group received no medication and was allowed ad lib access to water during a simulated saturation dive. The dehydrated group received intravenous 2 mg x kg(-1) Lasix (a diuretic medication) without access to water throughout the dive. Animals were then compressed on air to 110 ft of seawater (fsw, 4.33 ATA) for 22 h and brought directly to the surface at a rate of 30 fsw x min(-1) (0.91 ATA x min(-1)). Outcomes of death and non-fatal central nervous system (CNS) or cardiopulmonary DCS were recorded. RESULTS: In the hydrated group (n=31): DCS=10, cardiopulmonary DCS=9, CNS DCS=2, Death=4. In the dehydrated group (n=26): DCS=19, cardiopulmonary DCS=19, CNS DCS=6, Death=9. Dehydration significantly increased the overall risk of severe DCS and death. Specifically, it increased the risk of cardiopulmonary DCS, and showed a trend toward increased

CNS DCS. In addition, dehydrated subjects manifested cardiopulmonary DCS sooner and showed a trend toward more rapid death ($p < 0.1$). CONCLUSION: Hydration status at the time of decompression significantly influences the incidence and time to onset of DCS in this model.

Publication Types: Evaluation Studies
Research Support, U.S. Gov't, Non-P.H.S.
PMID: 16491576

58: J Clin Pathol. 2006 May;59(5):489-91. Epub 2006 Feb 17. Relevance of postmortem radiology to the diagnosis of fatal cerebral gas embolism from compressed air diving. Cole AJ, Griffiths D, Lavender S, Summers P, Rich K.

Department of Radiology, the Townsville Hospital, Douglas, Queensland, Australia.

AIMS: To test the hypothesis that artefact caused by postmortem off-gassing is at least partly responsible for the presence of gas within the vascular system and tissues of the cadaver following death associated with compressed air diving.

METHODS: Controlled experiment sacrificing sheep after a period of simulated diving in a hyperbaric chamber and carrying out sequential postmortem computed tomography (CT) on the cadavers.

RESULTS: All the subject sheep developed significant quantities of gas in the vascular system within 24 hours, as demonstrated by CT and necropsy, while the control animals did not. CONCLUSIONS: The presence of gas in the vascular system of human cadavers following diving associated fatalities is to be expected, and is not necessarily connected with gas embolism following pulmonary barotrauma, as has previously been claimed.

PMID: 16489175

59: J Exp Biol. 2006 Mar;209(Pt 5):845-59.

The effects of depth, temperature and food ingestion on the foraging energetics of a diving endotherm, the double-crested cormorant (*Phalacrocorax auritus*).

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Avian divers are confronted with a number of physiological challenges when foraging in cold water, especially at depth. Besides the obvious constraint imposed by the necessity to return to the surface for gas exchange, cold water temperatures and a reduction in body insulation due to the increase in pressure with dive depth will elevate the energetic costs of foraging in these endotherm divers. The complex effect that depth has on the diving energetics of aquatic birds has largely been ignored. To date, no study has assessed the impact of depth on diving energetics over a significant depth range, naturally encountered by the diver. We used open-circuit respirometry to study the energetic requirements of a foot-propelled pursuit diver, the double-crested cormorant (*Phalacrocorax auritus*), when diving in a shallow (1 m) and deep (10 m) dive tank and when resting in air and water. We also investigated the modifying effects of air or water temperature and feeding status on the costs associated with diving and resting. Of all factors investigated, dive depth exercised the strongest influence on diving metabolic rate. Diving to 10 m depth increased metabolic rate on average by 22% when compared with shallow diving. Declining temperatures in air and water significantly elevated metabolic rate of cormorants resting in air and water as well as during diving. Feeding before resting in water or diving increased metabolic rate by 5-8% for at least 2 h. Cormorants maintained an elevated stomach temperature (>42 degrees C) when resting in water and during diving, even at cold temperatures. The elevated dive costs during deep diving, when compared with shallow diving, are most likely a consequence of the increased thermoregulatory costs associated with a greater heat loss to the water at depth. Nevertheless, our study shows that dive costs in double-crested cormorants are similar to those of other foot-propelled avian divers.

PMID: 16481574

60: Neurology. 2006 Feb 14;66(3):451-2.

Lower motor neuron weakness after diving-related decompression.

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Publication Types: Case Reports
PMID: 16476956

61: Respir Physiol Neurobiol. 2006 Feb 28;150(2-3):220-32. Epub 2005 Apr 19.

The surface activity of pulmonary surfactant from diving mammals.

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Pinnipeds (seals and sea lions) have developed a specialised respiratory system to cope with living in a marine environment. They have a highly reinforced lung that can completely collapse and reinflate during diving without any apparent side effects. These animals may also have a specialised surfactant system to augment the morphological adaptations. The surface activity of surfactant from four species of pinniped (California sea lion, Northern elephant seal, Northern fur seal and Ringed seal) was measured using a captive bubble surfactometer (CBS), and compared to two terrestrial species (sheep and cow). The surfactant of Northern elephant seal, Northern fur seal and Ringed seal was unable to reduce surface tension (γ) to normal levels after 5 min adsorption (61.2, 36.7, and 46.2 \pm 1.7 mN/m, respectively), but California sea lion was able to reach the levels of the cow and sheep (23.4 mN/m for California sea lion, 21.6 \pm 0.3 and 23.0 \pm 1.5 mN/m for cow and sheep, respectively). All pinnipeds were also unable to obtain the very low γ (min) achieved by cow (1.4 \pm 0.1 mN/m) and sheep (1.5 \pm 0.4 mN/m). These results suggest that reducing surface tension to very low values is not the primary function of surfactant in pinnipeds as it is in terrestrial mammals, but that an anti-adhesive surfactant is

more important to enable the lungs to reopen following collapse during deep diving.

Publication Types: Comparative Study
Research Support, Non-U.S. Gov't

PMID: 16476655

62: Rheumatology (Oxford). 2006 Jul;45(7):855-8. Epub 2006 Jan 25.

Risk factors for dysbaric osteonecrosis.

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OBJECTIVES: Dysbaric osteonecrosis (DON) is a complication of ineffective decompression following exposure to high-pressure environments. This study was designed to determine risk factors for the occurrence of DON in divers. METHODS: Fifty-six male divers received skeletal examinations by radiography to assess the occurrence of DON. A questionnaire was used to obtain clinical and diving information, including diving experience and maximum diving depth. Blood samples were collected to analyse the levels of plasminogen activator inhibitor (PAI)-1, cholesterol, triglyceride, low-density lipoprotein, very low-density lipoprotein, high-density lipoprotein, apolipoprotein A1 and apolipoprotein B. RESULTS: Lesions of DON were detected in 31 of the 56 (55%) divers. Multivariate logistic regression analysis showed that high levels of PAI-1, a coagulation marker (odds ratio 4.281; $P=0.0296$) and great maximum diving depth (odds ratio 5.627; $P=0.0231$) were independent predictors of DON. CONCLUSIONS: This study has shown the presence of coagulation abnormality in divers with DON. This result suggests that a pharmacological approach incorporating the use of an anticoagulant may represent a potential strategy for the prevention of DON.

Publication Types: Research Support, Non-U.S. Gov't

PMID: 16436490

63: Forensic Sci Int. 2006 Dec 20;164(2-3):122-5. Epub 2006 Jan 19.

Comparison of pulmonary autopsy findings of the rats drowned at surface and 50 ft depth.

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INTRODUCTION: When a body is recovered from the water after a fatal SCUBA diving accident, it is useful to know if the diver was under pressure or not when he/she took his/her last breath, in order to determine the cause and manner of the death. If the victim was under pressure, the air remained in the lungs of the diver will be equal to the environmental pressure. If the body comes to the surface, the air in the lung will expand according to the Boyle's Gas Law and give mechanical damage to the surrounding tissues, due to decreases in environmental pressure. We designed an experimental study to see the difference in pulmonary autopsy findings of the rats that drowned under normobaric and hyperbaric conditions. METHOD: Forty five male, 250-300 g, Sprague Downey adult rats were divided into three groups. Two groups of rats were drowned under normobaric conditions (Groups DS Group DSS) and the third group at 50 ft pressure (Group DD). The pulmonary autopsy findings of the groups were compared. In the light microscopy, the number of the microscopic fields (x10) containing at least one emphysematous area with longitudinal dimension greater than 300 micro m were compared among the groups. RESULTS: The gross examination revealed a prominent swelling of the lungs in all rats in the Group DD, in comparison to that of the Groups DS and DSS. The number of the microscopic fields, which included at least one emphysematous area with longitudinal dimension greater than 300 micro m out of 150 fields from each of the groups DS, DSS and DD, were 88, 101 and 115 respectively. The difference between the group DS and DD was found to be statistically significant. CONCLUSION: We conclude that in investigating the fatal diving accidents, pulmonary autopsy findings give valuable information

whether the death occurred at the surface or at the depth.

PMID: 16427229

64: J Forensic Sci. 2006 Jan;51(1):137-9.

Aqua-eroticum: an unusual autoerotic fatality in a lake involving a home-made diving apparatus.

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The term Aqua-eroticum was first introduced in 1984 by Sivaloganathan to describe the unusual autoerotic death of a man using submersion as an asphyxia method. This was the first case of that kind, and since then, no other case of autoerotic submersion has been reported, nor other autoerotic fatality in open water. Here we report the case of a 25-year-old man, nude under a home-made plastic body suit, overdressed for the season with winter clothes and restrained by complex bondage. He was submersed, tied underwater to a boat and was using a home-made diving apparatus for air supply. Death was ruled as accidental autoerotic asphyxia from rebreathing, caused by the faulty air-supply device.

Publication Types: Case Reports
PMID: 16423240

65: Aviat Space Environ Med. 2006 Jan;77(1):13-9.

Decompression schedule optimization with an isoprobabilistic risk of decompression sickness.

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INTRODUCTION: Divers use decompression schedules to reduce the probability of occurrence of decompression sickness when returning to the surface at the end of a dive. The probability of decompression sickness resulting from these schedules varies across different dives and the models used to generate them. Usually the diver is unaware of this variance in risk. This paper describes an investigation into the feasibility of producing optimized isoprobabilistic decompression

schedules that minimize the time it takes for a diver to reach the surface. METHODS: The decompression schedules were optimized using the sequential quadratic programming method (SQP), which minimizes the ascent time for a given probability of decompression sickness. The U.S. linear-exponential multi-gas model was used to calculate an estimate of the probability of decompression sickness for a given dive. In particular 1.3-bar oxygen in helium rebreather bounce dives to between 18 m and 81 m were considered and compared against the UK Navy QinetiQ 90 tables for a similar estimate of probability of decompression sickness. RESULTS: The SQP method reliably produced schedules with fast and stable convergence to an optimized solution. Comparison of the optimized decompression schedules with the QinetiQ 90 schedules showed similar stop times for shallow dives to 18 m. For dives with a maximum depth of 39 m to 81 m, optimizing the decompression resulted in savings in decompression time of up to 30 min. CONCLUSIONS: This paper has shown that it is feasible to produce optimized iso-probabilistic decompression tables given a reliable risk model for decompression sickness and appropriate dive trials.

PMID: 16422448

66: Knee Surg Sports Traumatol Arthrosc. 2006 Sep;14(9):907-14. Epub 2006 Jan 17.

Back pain and degenerative abnormalities in the spine of young elite divers: a 5-year follow-up magnetic resonance imaging study.

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Several studies have been published on disc degeneration among young athletes in sports with great demands on the back, but few on competitive divers; however, there are no long-term follow-up studies. Twenty elite divers between 10 and 21 years of age, with the highest possible national ranking, were selected at random without knowledge of previous or present back injuries

or symptoms for an MRI study of the thoraco-lumbar spine in a 5-year longitudinal study. The occurrence of MRI abnormalities and their correlation with back pain were evaluated. Eighty-nine percent of the divers had a history of back pain and the median age at the first episode of back pain was 15 years. Sixty-five percent of the divers had MRI abnormalities in the thoraco-lumbar spine already at baseline. Only one diver without abnormalities at baseline had developed abnormalities at follow-up. Deterioration of any type of abnormality was found in 9 of 17 (53%) divers. Including all disc levels in all divers, the total number of abnormalities increased by 29% at follow-up, as compared to baseline. The most common abnormalities were reduced disc signal, Schmorl's nodes, and disc height reduction. Since almost all divers had previous or present back pain, a differentiated analysis of the relationship between pain and MRI findings was not possible. However, the high frequency of both back pain and MRI changes suggests a causal relationship. In conclusion, elite divers had high frequency of back pain at young ages and they run a high risk of developing degenerative abnormalities of the thoraco-lumbar spine, probably due to injuries to the spine during the growth spurt. Publication Types: Research Support, Non-U.S. Gov't PMID: 16416326

67: Respir Physiol Neurobiol. 2006 Aug;153(1):66-77. Epub 2006 Jan 18.

Deep diving mammals: Dive behavior and circulatory adjustments contribute to bends avoidance.

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A mathematical model was created that predicted blood and tissue N₂ tension (P(N₂)) during breath-hold diving. Measured muscle P(N₂) from the bottlenose dolphin after diving repeatedly to 100 m (*Tursiops truncatus* [Ridgway and Howard, 1979, Science, 4423, 1182-1183]) was

compared with predictions from the model. Lung collapse was modelled as a 100% pulmonary shunt which yielded tissue P(N₂) similar to those reported for the dolphin. On the other hand, predicted muscle P(N₂) for an animal with a dive response, reducing cardiac output by 66% from surface values (20.5 to 6.81 x min(-1)), also agreed well with observed values in the absence of lung collapse. In fact, modelling indicated that both cardiovascular adjustments and dive behaviour are important in reducing N₂ uptake during diving and enhancing safe transfer of tissue and blood N₂ back to the lung immediately before coming to the surface. In particular, diving bradycardia during the descent and bottom phase together with a reduced ascent rate and increase in heart rate reduced mixed venous P(N₂) upon return to the surface by as much as 45%. This has important implications as small reductions in inert gas load (approximately 5%) can substantially reduce decompression sickness (DCS) risk by as much as 50% (Fahlman et al., 2001, J. Appl. Physiol. 91, 2720-2729).

Publication Types: Comparative Study
Research Support, Non-U.S. Gov't
PMID: 16413835

68: Spine J. 2006 Jan-Feb;6(1):44-9.
Epub 2005 Dec 6.

Diving injuries of the cervical spine in amateur divers.

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BACKGROUND CONTEXT: Diving injuries are the cause of potentially devastating trauma, primarily affecting the cervical spine.

PURPOSE: Our purpose was to describe our experience with diving injuries treatment.

STUDY DESIGN: Retrospective review.

PATIENT SAMPLE: Twenty patients with diving injuries.

OUTCOME MEASURES: Using the American Spinal Injury Association (ASIA) impairment scales as the primary outcome measure, the patients' neurological status before and after treatment

was assessed. In this way we were able to draw conclusions about neurological improvement or deterioration in response to conservative or operative treatment.

METHODS: We retrospectively reviewed 20 patients with diving injuries of the cervical spine who were admitted to our institute over a 34-year period from 1970 until 2004.

RESULTS: The typical patient profile was of a young, healthy, athletic male who suffered an injury to the cervical spine after diving into shallow water. The number of cases corresponds to 2.6% of all admitted cervical spine injuries. All injuries occurred between May and September.

The most commonly fractured vertebrae were C5 and C6. Four patients were treated operatively and 16 conservatively.

The indications for surgical treatment were posttraumatic instability and persistent neurological deficit. The mean follow-up of the patients was 17 years. Five patients died within the first month of their hospitalization and 1 patient died 1 year after his injury.

Of the 14 patients who were available for follow-up 5 years past injury time, 6 improved neurologically and 8 remained unchanged in relation to their neurology upon admission. Of the 11 patients who were available for follow-up 10 years past injury time, 9 remained neurologically unchanged, 1 deteriorated, and 1 improved in relation to their neurology in the 5-year follow-up.

CONCLUSION: Diving injuries of the cervical spine demonstrate high mortality and morbidity rates. Recovery depends on the severity of the initial neurological damage. Conservative treatment is justified in specific patients and can lead to improvement of the initial neurological deficit.

Publication Types: Comparative Study
PMID: 16413447

69: Clin Neuropsychol. 2006 Feb;20(1):160-76.

Apnea diving: long-term neurocognitive sequelae of repeated hypoxemia.

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This article examines the neurocognitive sequelae of repeated exposure to hypoxemia in apnea (breath-hold) divers. A brief review of the literature on the physiological and neurological adaptations involved in the "human diving reflex" is presented. The results from a neuropsychological investigation of N = 21 elite apnea divers are evaluated. Standard neuropsychological tests, with known sensitivity to mild brain insults, included speed of visuo-motor responding, speed of language comprehension, response inhibition, and visual and verbal attention and recall tasks. Results indicated that the breath-hold divers performed tasks within the average range compared to norms on all tests, suggesting that 1-20 years of repeated exposure to hypoxemia including multiple adverse neurological events did not impact on performance on standard neuropsychological tasks. The results are discussed in relation to implications for clinical conditions such as sleep apnea, respiratory disorders, altitude sickness, and recreational apnea activities.
PMID: 16410228

70: Clin J Sport Med. 2006 Jan;16(1):76-8.
Bilateral carotid artery dissection caused by springboard diving.
Furtner M, Werner P, Felber S, Schmidauer C.
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Publication Types: Case Reports
PMID: 16377982

71: J Comp Physiol B. 2006 Mar;176(3):265-75. Epub 2005 Dec 8.
Substitution of heat from exercise and digestion by ducks diving for mussels at varying depths and temperatures.
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Diving birds can lose significant body heat to cold water, but costs can be reduced if heat from exercising muscles or the heat increment of feeding (HIF) can substitute for thermogenesis. Potential for substitution depends jointly on the rate of heat loss,

the rate of heat produced by exercise, and the level of HIF. To explore these interactions, we measured oxygen consumption by lesser scaup ducks (*Aythya affinis*) diving to depths of 1.2 and 2 m at thermoneutral (23 degrees C) and sub-thermoneutral (18 and 8 degrees C) temperatures. Birds dove while fasted and when feeding on blue mussels (*Mytilus edulis*). Substitution occurred if HIF or costs of diving above resting metabolic rate (RMR) were lower at 18 or 8 degrees C than at 23 degrees C, indicating reduction in the thermoregulatory part of RMR. For fasted scaup diving to 1.2 m, substitution from exercise heat was not apparent at either 18 or 8 degrees C. At 2 m depth, dive costs above RMR were reduced by 5% at 18 degrees C and by 40% at 8 degrees C, indicating substitution. At 1.2 m depth (with voluntary intake of only 14-17% of maintenance requirements), HIF did not differ between temperatures, indicating no substitution. However, at 2 m (intake 13-25% of maintenance), substitution from HIF was 23% of metabolizable energy intake at 18 degrees C and 22% at 8 degrees C. These results show that even with low HIF due to low intake rates, substitution from HIF can add to substitution from the heat of exercise.

Publication Types: Research Support, Non-U.S. Gov't
Research Support, U.S. Gov't, Non-P.H.S.
PMID: 16341521

72: Comp Biochem Physiol C Toxicol Pharmacol. 2006 Mar-Apr;142(3-4):198-204. Epub 2005 Nov 2.
Antioxidant enzymes in ringed seal tissues: potential protection against dive-associated ischemia/reperfusion.
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Diving seals experience heart rate reduction and preferential distribution of the oxygenated blood flow to the heart and brain, widespread peripheral vasoconstriction, and selective ischemia in the most hypoxia-

tolerant tissues. The first breath after the dive restores the oxygenated blood flow to all tissues and raises the potential for the production of reactive oxygen species (ROS). We hypothesized that in order to counteract the damaging effects of ROS and to tolerate repetitive cycles of ischemia/reperfusion associated with diving, ringed seal (*Phoca hispida*) tissues have elevated activities of antioxidant enzymes. Activities of superoxide dismutase (SOD), catalase (CAT), glutathione peroxidase (GPx) and glutathione-S-transferase (GST) were measured by spectrophotometric techniques in heart, kidney, liver, lung, and muscle extracts of ringed seals and domestic pigs (*Sus scrofa*). The results suggest that in ringed seal heart SOD, GPx and GST activities are an efficient protective mechanism for counteracting ROS production and its deleterious effects. Apparently CAT activity in seal liver and GPx activity in seal muscle participate in the removal of hydroperoxides, while seal lung appears to be protected from oxidative damage by SOD and GPx activities.

Publication Types: Comparative Study
Research Support, Non-U.S. Gov't

PMID: 16269268

73: *Respir Physiol Neurobiol.* 2006 Jun;152(2):152-68. Epub 2005 Sep 1.

The composition of pulmonary surfactant from diving mammals.

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Maintaining a functional pulmonary surfactant system at depth is critical for diving mammals to ensure that inspiration is possible upon re-emergence. The lipid and protein composition of lavage extracts from three pinniped species (California sea lion, Northern elephant seal and Ringed seal) were compared to several terrestrial species. Lavage samples were purified using a NaBr discontinuous gradient. Concentrations of phospholipid classes and molecular species were measured using electrospray ionisation mass

spectrometry, cholesterol was measured using high-performance liquid chromatography, surfactant protein A (SP-A) and SP-B were measured using enzyme-linked immunosorbent assays. There were small differences in phospholipid classes, with a lower level of anionic surfactant phospholipids, PG and PI, between diving and terrestrial mammals. There were no differences in PL saturation or SP-A levels between species. PC16:0/14:0, PC16:0/16:1, PC16:0/16:0, long chain PI species and the total concentrations of alkyl-acyl species of PC and PG as a ratio of diacyl species were increased in diving mammals, whereas concentrations of PC16:0/18:1, PG16:0/16:0 and PG16:0/18:1 were decreased. Cholesterol levels were very variable between species and SP-B was very low in diving mammals. These differences may explain the very poor surface activity of pinniped surfactant that we have previously described [Miller, N.J., Daniels, C.B., Schürch, S., Schoel, W.M., Orgeig, S., 2005. The surface activity of pulmonary surfactant from diving mammals. *Respir. Physiol. Neurobiol.* 150 (2006) 220-232], supporting the hypothesis that pinniped surfactant has primarily an anti-adhesive function to meet the challenges of regularly collapsing lungs.

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